MULTIMEDIA UNIVERSITY

STUDENT ID NO

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# MULTIMEDIA UNIVERSITY

# FINAL EXAMINATION

**TRIMESTER 1, 2019/2020**

## EMG 2016 – ELECTROMAGNETIC THEORY

(TE, RE)

17 OCTOBER 2019
09:00 a.m – 11:00 a.m
(2 Hours)

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**INSTRUCTIONS TO STUDENT**

1. This question paper consists of 8 pages with 4 Questions only.
2. Attempt **ALL FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.
4. Please submit the completed Smith Chart together with the answer booklet.

## Question 1

(a) A voltage generator with $v_g = 5\cos(2\pi \times 10^9 t)\, V$ and internal impedance $Z_g$ = 50Ω is connected to a 50Ω lossless air-spaced transmission line. The line length is 5cm and it is terminated in a load with impedance $Z_L$ = (100 - $j$100) Ω. Find:

i) The reflection coefficient, Γ.

[3 marks]

ii) The input impedance $Z_{in}$ at the input to the transmission line.

[5 marks]

iii) The input voltage $\tilde{V}_i$ and input current $\tilde{I}_i$.

[4 marks]

(b) Measurements on a lossless transmission line of characteristic impedance $Z_0$=75Ω show a standing-wave ratio of 2.4 and the first two voltage minima nearest to the load at 0.335m and 1.235m. Use a Smith chart to:

i) Determine the load impedance $Z_L$, the load admittance $Y_L$.

[9 marks]

ii) Find the location nearest to the load and the length of a shunt short-circuited stub required to match $Z_L$ to the line.

[4 marks]

**Continued...**

## Question 2

(a) A 125 Ω resistive load is preceded by a λ/4 section of a 50 Ω lossless line, which itself is preceded by another $0.3\lambda$ section of an 80 Ω lossless line, which is also preceded by another a λ/4 section of a 50 Ω lossless line. What is the input impedance?

[13 marks]

(b) A 50-cm-long metal rod rotates about the $z$-axis at 90 revolutions per minute, with end 1 fixed at the origin as shown in Figure Q2. Determine the induced electromotive force (EMF), $V_{12}$ if $B_0 = \hat{z}2 \times 10^{-4}$ $T$.

[12 Marks]

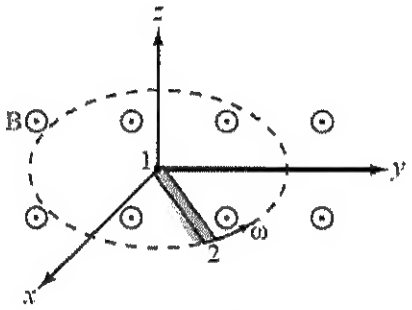



Figure **Q2**

**Continued...**

**Question 3**

(a) Provide two equations to show that for any uniform plane wave travelling in an arbitrary direction denoted by the unit vector $\hat{k}$, the magnetic field phasor $\tilde{H}$ is related to the electric field phasor $\tilde{E}$.

[3 Marks]

(b) Explain briefly the polarization of a uniform plane wave.

[4 Marks]

(c) The magnetic field component of a plane wave in a lossless dielectric is given by $\vec{H}. = 30\sin(2\pi \times 10^8 t - 5x)\hat{a}_z$ (mA/m).

i) If $\mu_r = 1$, find $\varepsilon_r$. [2 Marks]

ii) Calculate the wavelength ($\lambda$) and wave velocity, $u$ [3 Marks]

iii) Determine the wave impedance, $\eta$ [3 Marks]

iv) Determine the polarization of the wave [3 Marks]

v) Find the corresponding electric field component $\vec{E}$ [4 Marks]

vi) Find the displacement current density $J_d$ [3 Marks]

**Continued...**

## Question 4

(a) An air filled copper waveguide has dimensions of $a = 2.286$ cm, and $b = 1.016$ cm. Find the cut-off frequencies of the first four propagating modes. Determine the dominant mode.

[11 marks]

(b) For an air filled waveguide. It has a field component of

$$E_z = 30 \sin\left(\frac{2\pi}{a}x\right) \sin\left(\frac{\pi}{b}y\right) \cos(40\pi \times 10^9 t - \beta z)\, V/m$$

where a = 5 cm and b = 2 cm, determine the following:

(i) The mode of propagation.

[2 marks]

(ii) Phase constant, $\beta$, given the cut-off frequency is 9.6 GHz.

[3 marks]

(iii) Phase velocity, $u_p$.

[3 marks]

(iv) Propagation wavelength, $\lambda_g$.

[3 marks]

(v) Wave impedance of the propagating mode in part (b) (i).

[3 marks]

**End of Page**

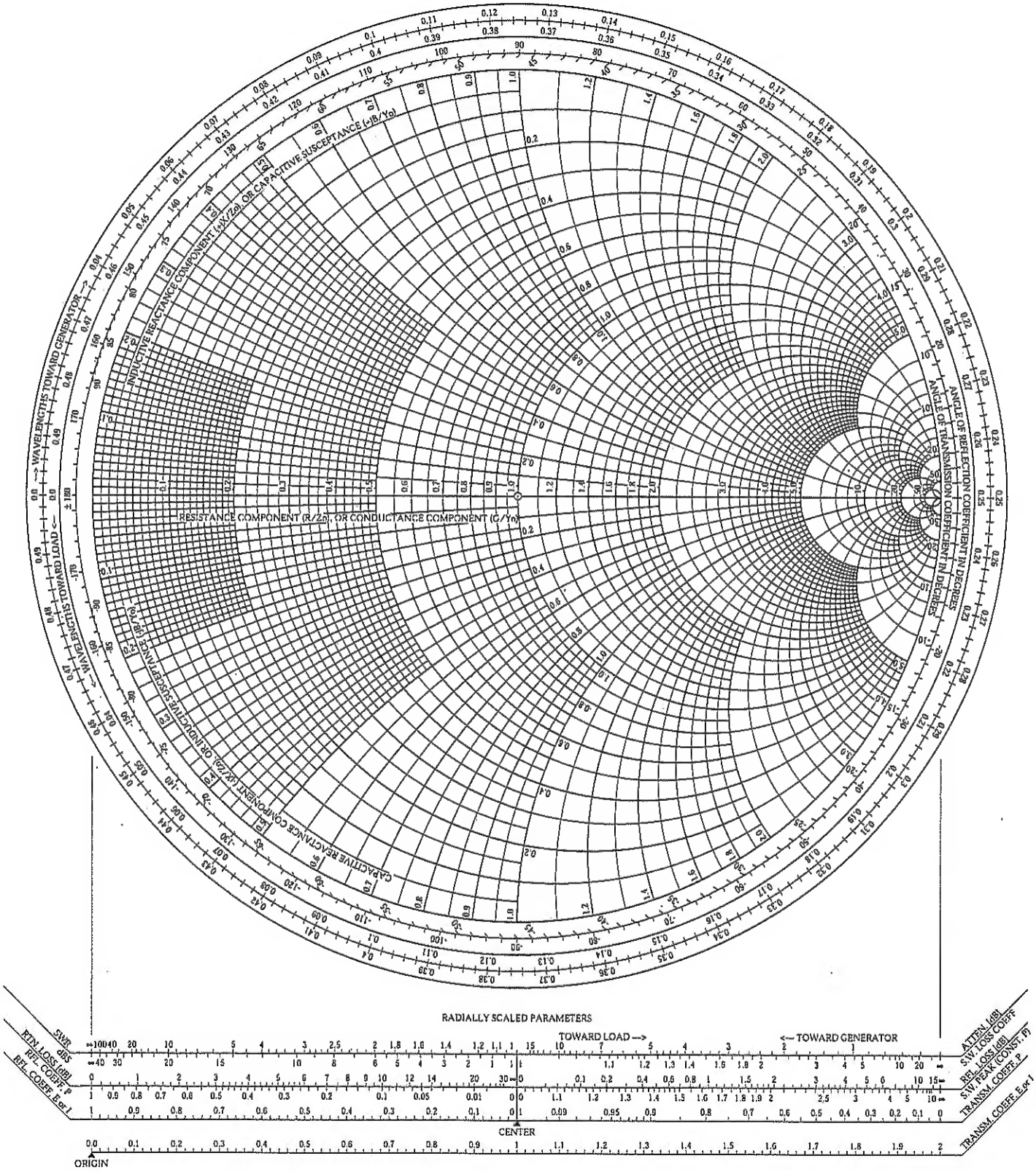
## Appendix

### FUNDAMENTAL PHYSICAL CONSTANTS

Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m
Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ H/m
Speed of light in vacuum c = $3 \times 10^8$ $m/s$
Intrinsic impedance of free space $\eta_0 = 377\Omega$

# The Complete Smith Chart

Black Magic Design



# The Complete Smith Chart

## Black Magic Design